



Standard Test Methods for Fire Tests of Roof Coverings¹

This standard is issued under the fixed designation E108; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This fire-test-response standard covers the measurement of the relative fire characteristics of roof coverings under simulated fire originating outside the building. It is applicable to roof coverings intended for installation on either combustible or noncombustible decks when applied as intended for use. The following test methods are included:

- 1.1.1 Intermittent flame exposure test.
- 1.1.2 Spread of flame test.
- 1.1.3 Burning brand test.
- 1.1.4 Flying brand test.
- 1.1.5 Rain test.

1.2 Three classes of fire test exposure are described:

1.2.1 *Class A Tests* are applicable to roof coverings that are effective against severe test exposure, afford a high degree of fire protection to the roof deck, do not slip from position, and do not present a flying brand hazard.

1.2.2 *Class B Tests* are applicable to roof coverings that are effective against moderate test exposure, afford a moderate degree of fire protection to the roof deck, do not slip from position, and do not present a flying brand hazard.

1.2.3 *Class C Tests* are applicable to roof coverings that are effective against light test exposure, afford a light degree of fire protection to the roof deck, do not slip from position, and do not present a flying brand hazard.

1.3 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.4 *This standard is used to measure and describe the response of materials, products, or assemblies to heat and flame under controlled laboratory conditions, but does not by itself incorporate all factors required for fire hazard or fire risk assessment of the materials, products or assemblies under actual fire conditions.*

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the*

responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.6 The text of this standard references notes and footnotes that provide explanatory information. These notes and footnotes, excluding those in tables and figures, shall not be considered as requirements of this standard.

2. Referenced Documents

2.1 ASTM Standards:²

- D225 Specification for Asphalt Shingles (Organic Felt) Surfaced With Mineral Granules
- D226 Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
- D227 Specification for Coal-Tar-Saturated Organic Felt Used in Roofing and Waterproofing
- D312 Specification for Asphalt Used in Roofing
- D450 Specification for Coal-Tar Pitch Used in Roofing, Dampproofing, and Waterproofing
- D1227 Specification for Emulsified Asphalt Used as a Protective Coating for Roofing
- D2178 Specification for Asphalt Glass Felt Used in Roofing and Waterproofing
- D2626 Specification for Asphalt-Saturated and Coated Organic Felt Base Sheet Used in Roofing
- D2898 Practice for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing
- D3018 Specification for Class A Asphalt Shingles Surfaced with Mineral Granules
- D3158 Specification for Asphalt Saturated and Coated Organic Felt Used in Roofing³
- D3378 Specification for Asphalt-Saturated and Coated Asbestos Felt Base Sheet Used in Roofing³
- D3462 Specification for Asphalt Shingles Made from Glass Felt and Surfaced with Mineral Granules
- D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Base Materials

¹ These test methods are under the jurisdiction of ASTM Committee E05 on Fire Standards and are the direct responsibility of Subcommittee E05.14 on External Fire Exposures.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Withdrawn. The last approved version of this historical standard is referenced on www.astm.org.

D4444 Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters

2.2 UL Standards:

UL 55A Materials for Built-Up Roof Coverings⁴

UL790 Tests for Fire Resistance of Roof Covering Materials⁴

2.3 NFPA Standards:

NFPA 256 Tests of Roof Coverings⁵

3. Terminology

3.1 Definitions: Definitions:

3.1.1 *significant lateral spread*—surface flaming beyond 1-ft. from the lead edge, extending outward to both lateral edges of the test deck assembly or to both inner edges of metal batten strips, if used, along the side edges of the test deck assembly.

3.1.2 *sustained flaming*—any flaming which continues uninterrupted for 5 seconds or more.

3.1.3 *prepared roof covering*—products consisting of shingles, tiles, panels or rolled materials that are typically used for high slope roof applications which are applied directly to the roof deck (usually with one or more layers of underlayment and with or without battens) in accordance with installation instructions supplied with the products.

4. Significance and Use

4.1 The test methods described herein are intended to provide a basis for relative comparison of roof coverings. The test methods include simulated fire exposure to the outside of the roof coverings, and, where applicable, a determination as to whether the fire performance characteristics of the roof coverings will be adversely affected by prolonged exposure to rain.

4.2 These test methods measure the surface spread of flame and the ability of the roof covering material or system to resist fire penetration from the exterior to the underside of a roof deck under the conditions of exposure.

4.3 These test methods also provide criteria to determine if the roof covering material will develop flying burning material, identified as flying brands, when subjected to a 12-mph (5.3-m/s) wind during the simulated fire exposure tests.

4.4 These test methods do not necessarily illustrate the expected performance of roof coverings under all actual fire conditions, but they do provide a basis for comparing roof covering materials when subjected to fire sources that are described herein.

4.5 These test methods do not provide any basis for determining the fire resistance characteristics when exposed to a fire originating in the building to which the roofing material is applied.

4.6 The test methods described herein involve calibrating the test equipment using a calibration deck inclined at a slope of 5 in. per horizontal ft (0.416:1). The tests described herein are performed on test decks inclined at slopes up to and including 5 in. per horizontal ft. The severity of the test

exposure decreases as the slope of the test deck decreases below 5 in. per horizontal ft.

5. Apparatus and Calibration

5.1 The essential elements of the fire test apparatus used for tests described in Sections 8-11 are illustrated in Fig. 1. They consist of the following:

(a) A test deck to which the roof-covering materials to be tested are applied, mounted on a framework. The incline of the framework is to be adjustable with respect to incline (slope) as well as the vertical position for fire testing decks with insulated roof coverings.

(b) A construction of noncombustible boards, mounted on the front of the framework to simulate eaves and cornices.

(c) A gas burner (for intermittent-flame, spread-of-flame and flying brand tests) consisting of a 44-in. (1.12 m) length of nominal 2 in. (2.38 in./60.3 mm OD) pipe having a 1/2-in. (12.7 mm) wide, 36-in. (0.91 m) long slot in the side toward the test deck. The burner is to be supplied with gas at both ends through nominal 1-in. (1.32 in./33.4 mm OD) pipe to provide uniform gas pressure at the burner assembly.

(d) A blower and air duct for providing the required wind conditions.

(e) Adjustable fins mounted inside the air duct to straighten the air stream and reduce turbulence.

(f) A baffle mounted on the back edge of the test deck to prevent backfiring under the deck.

(g) Noncombustible boards extended from the sides and bottom of the air duct to the simulated-eaves-and-cornices construction mentioned in (b) (not used during burning brand).

(h) Fire calibration exposure pattern – (See 5.5.5).

5.1.1 During the test:

5.1.1.1 Provide free outlet to outside air beyond and above the test apparatus to exhaust air introduced into the test room by the blower, and

5.1.1.2 Close all openings into the test room other than those mentioned in 5.1.1, such as doors and windows.

5.2 The temperature of the air supplied by the blower shall be maintained between 50 and 90°F (10 and 32°C).

5.3 Fig. 2 illustrates an example of the essential elements of a rain test apparatus.

5.4 Calibrating Air Current:

5.4.1 Set up the test apparatus for the intermittent flame test and position a bare 3-ft, 4-in. by 4-ft, 4 in. (1 m by 1.3 m) plywood, gypsum board or fiber cement board calibration deck on the framework at an incline of 5 in. per horizontal ft (0.416:1).

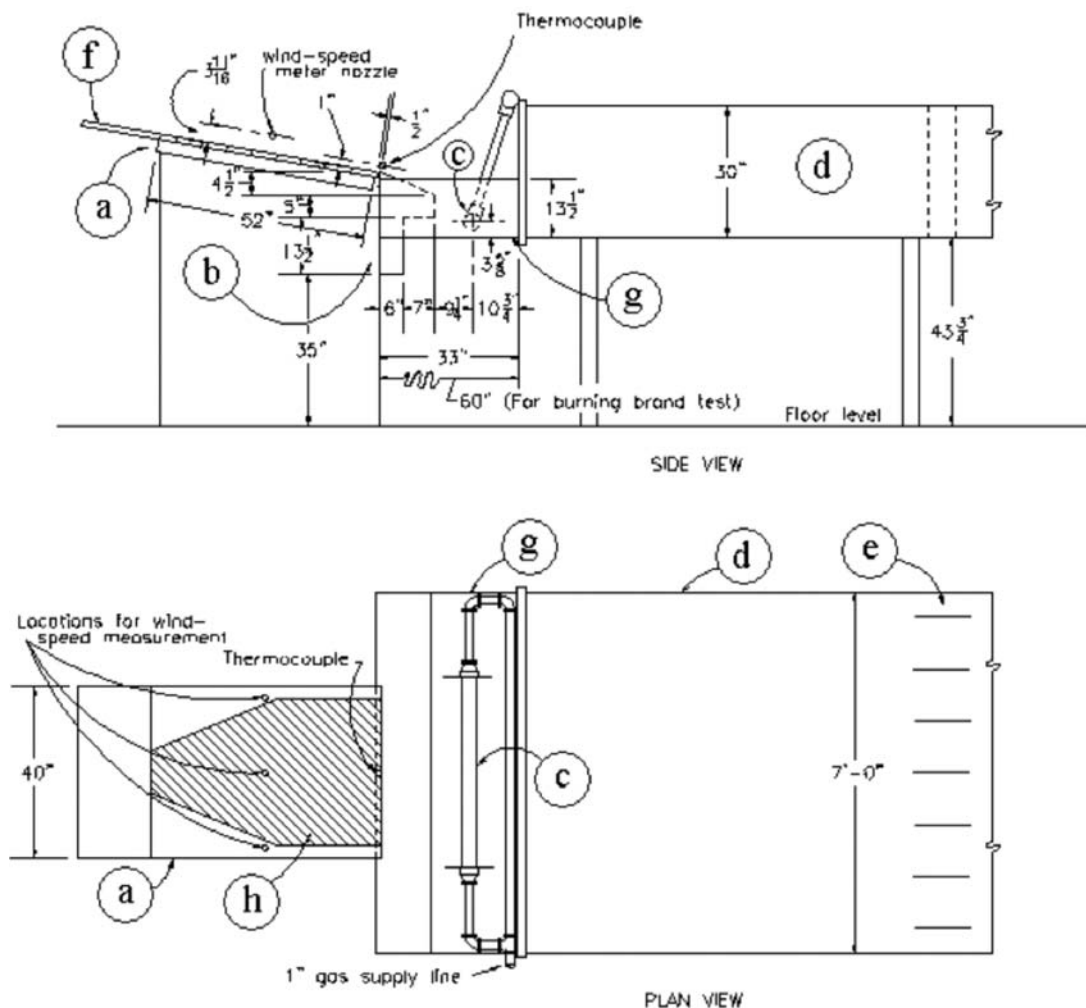
5.4.2 Measure the air velocity midway up the slope of the calibration deck at its center and 3 in. (76 mm) from each edge.

NOTE 1—Any direct reading instrument with scale graduated in increments of not more than 20 ft/min (6 m/min) or any timed instrument with scale graduated (for a 1 min timed reading) in increments of not more than 5 ft/min (1.5 m/min) will be suitable.

5.4.3 Position the center of the air measuring device at a nominal 3 1/16 in. (94 mm) above the surface. The air flow through and around the instrument shall be as free and undisturbed as possible.

⁴ Available from Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062.

⁵ Available from National Fire Protection Assoc., 1 Batterymarch Park, Quincy, MA 02269.



(See Appendix X1 for metric equivalents.)

FIG. 1 Schematic Drawing of Fire Test Apparatus

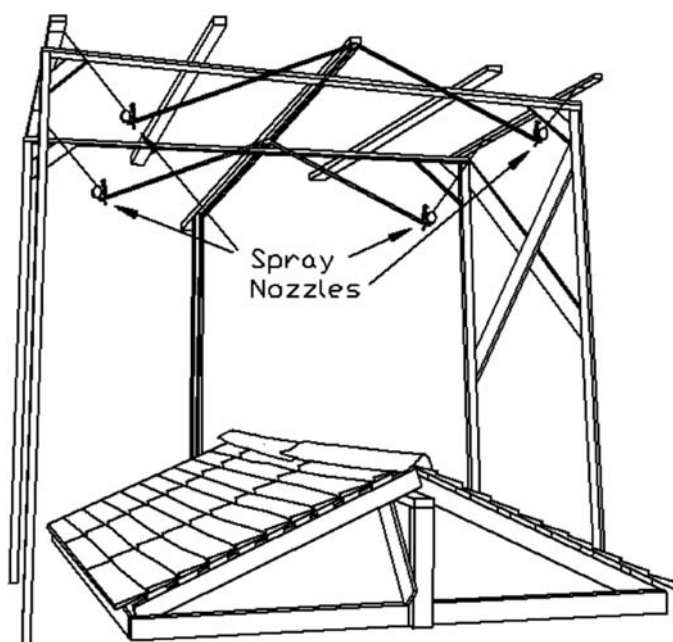


FIG. 2 Rain Test Apparatus

5.4.4 Adjust the air supply system to produce a 1 min timed average velocity of 1056 ± 44 ft/min corresponding to 12 ± 0.5 mph (5.3 ± 0.2 m/s) at each of the three locations detailed in 5.4.2. In order to comply with 5.5.5, it shall be permitted to adjust the 1-min time averaged velocity at each location by $\pm 5\%$ from the initial value within the range 1012 to 1100 ft/min (5.1 to 5.5 m/s). This deviation in an individual 1-min timed average velocity shall only be permitted when the average of the 1-min timed average velocity of all three locations is 12 ± 0.5 mph (5.3 ± 0.2 m/s).

5.5 Calibrating Flame Temperature:

5.5.1 Following the calibration of the air current described in 5.4, position a fiber cement board calibration deck, 4 ft, 4 in. (1.3 m) long on the framework at an incline of 5 in. per horizontal ft (0.416:1).

5.5.2 Measure the temperature with a No. 14 B & S gage (1.63 mm) Type K wire thermocouple located 1 in. (25 mm) above the surface and $\frac{1}{2}$ in. (13 mm) toward the source of the flame from the lower front edge of the calibration deck.

5.5.3 Adjust the gas flow to produce a 2 min average flame temperature of $1400 \pm 50^\circ\text{F}$ ($760 \pm 28^\circ\text{C}$) for Classes A and B and $1300 \pm 50^\circ\text{F}$ ($704 \pm 28^\circ\text{C}$) for Class C tests. Allow the

response of the thermocouple to the test flame to stabilize before the 2 min average flame temperature is measured. Base the 2 min average on temperatures recorded at 10 s intervals.

NOTE 2—It has been found that the gas flow generally corresponds to a heat supply rate within the range 21 000 to 22 000 Btu/min (369 to 387 kWh) for Class A or B samples and 18 000 to 19 000 Btu/min (316 to 334 kWh) for Class C samples.

5.5.4 Position the top surface of the leading edge of the calibration deck or the test sample flush with the top edge of the simulated eave within a tolerance of $-0 + \frac{1}{2}$ in. (13 mm).

5.5.5 When these calibration conditions are met, the flame shall be approximately 3 ft (0.9 m) wide at the bottom edge and in the center of the width of the calibration deck and the flame shall gradually narrow to approximately a 6 in. (0.15 m) width in the center of and at the top edge of the calibration deck. This described fire exposure pattern applied to the deck during flame calibration is shown in Fig. 1, Item h. Intermittent flashes of flame extending another 1 to 2 ft (0.3 to 0.6 m) beyond the top edge of the calibration deck shall be permitted.

5.6 Rain Test Calibration:

5.6.1 Measure the horizontal projected area over which each nozzle discharges water to the nearest square foot (square metre). Measure the discharge of water for each nozzle for 1 min.

5.6.2 Monitor the total water use during the test (a commercial water meter is suitable for this purpose). For a four day cycle the water usage shall be 42 ± 1 gal/ft² (1711 ± 41 L/m²). For a seven day cycle the water usage shall be 73 ± 1.7 gal/ft² (2975 ± 71 L/m²).

5.7 Frequency of Calibration:

5.7.1 Calibrate the apparatus for air velocity and flame temperature prior to each day's use. Calibrate the apparatus for flame temperature when shifting from Class A or B to Class C tests or vice versa.

5.7.2 Any indication of off-limit condition such as unusual flame appearance or flame contour, excess turbulence, or unusual noise shall be cause for calibration prior to further use.

5.7.3 For the Rain Test, visually check the water flow from each nozzle (for obvious water obstruction in the nozzle and uneven spray pattern) each day during the water cycle and make adjustments when necessary.

5.7.4 For the Rain Test, review the total water flow at the end of each day and at the end of each water cycle. Correct the cause of any off-limit conditions.

6. Preparation of Test Specimens

6.1 Construction of Test Decks:

6.1.1 The test deck for the intermittent flame exposure, burning brand tests, flying brand test, and rain test, except as specified in the following paragraphs, shall be 3 ft-4 in. (1.0 m) wide by 4 ft-4 in. (1.3 m) long and shall be made of No. 1 white pine lumber with not less than 8 % nor more than 12 % moisture content. The lumber shall be free of large or loose knots, sapwood, rot, or pitch pockets, and shall contain no edge knots. Individual deck boards shall be of nominal 1 by 8-in. lumber (S4S). Lay the boards across the shorter dimension of the test deck space $\frac{1}{4}$ in. (6 mm) apart and securely nail to two

nominal 2 by 4-in. wood battens located under and flush with the outer edges of the deck (Fig. 3). Decks so constructed shall be even and uniform.

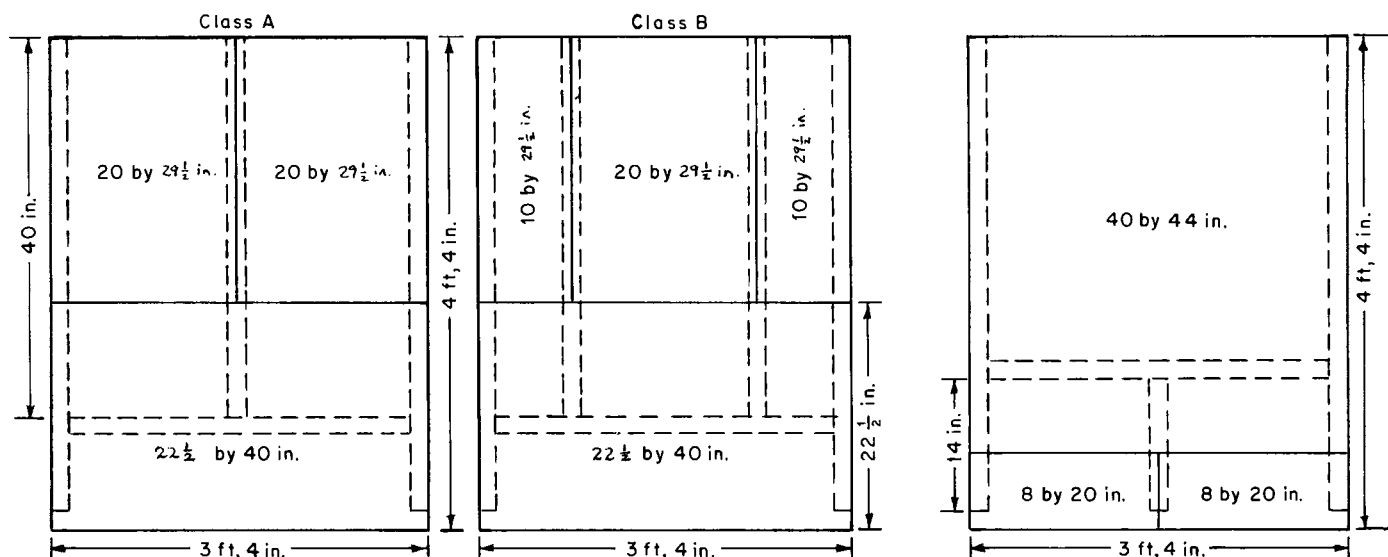
6.1.2 Where the roof covering is intended to be installed over other than solid deck, construct the test decks of nominal 1 by 4-in. lumber (S4S) spaced a minimum of $1\frac{1}{8}$ in. (41 mm) apart and securely nailed to two nominal 2 by 4-in. wood battens. The lumber shall be of the same quality as specified in 6.1.1.

6.1.3 Roof coverings are permitted to be applied to other test decks of the minimum thickness recommended by the manufacturer. This deviation shall be noted in the report. Plywood, if used, shall be exterior Type A-C grade with face and back veneers of Douglas fir conforming to PS1 for softwood plywood and shall be identified as a Group 1 species. Oriented Strand Board (OSB), if used, shall be marked as conforming to PS2. These decks shall have $\frac{1}{8}$ -in. (3.2-mm) vertical and horizontal joints located as specified in 6.1.1 with all vertical joints centered on nominal 2 by 4-in. wood battens. If wood battens or tongue and groove joints are specified for horizontal joints, this shall be so noted in reporting the tests. The decks for intermittent flame tests shall have a $\frac{1}{8}$ in. (3.2 mm) metric horizontal joint 8 in. (203 mm) from and parallel to the $3\frac{1}{2}$ ft (1.0 m) long leading edge. In addition, provide a $\frac{1}{8}$ in. (3.2 mm) metric vertical joint centered on the deck and extending from the leading edge of the deck to the $\frac{1}{8}$ in. (3.2 mm) metric horizontal joint. Since the lower $1\frac{1}{2}$ in. (38 mm) of this joint is not protected by the 2 by 4-in. batten, due to the mounting arrangement on the carriage, cover the underside of this joint from the end of the two-by-four to the leading edge of the deck by a piece of sheet steel, 2 in. (51 mm) wide.

6.1.4 For Classes A and B burning brand tests on decks other than 1 by 8-in. metric nominal lumber, the $\frac{1}{8}$ in. (3.2 mm) horizontal joint shall be $22\frac{1}{2}$ in. (572 mm) from and parallel to the leading edge of the deck. Class A test decks shall have a $\frac{1}{8}$ in. (3.2 mm) metric vertical joint centered on the deck that extends above the horizontal joint. For Class B test decks, provide two $\frac{1}{8}$ in. (3.2 mm) metric vertical joints, extending above the horizontal joint with each vertical joint located 10 in. (254 mm) from and parallel to the edge of the deck. For Class C burning brand test, provide five evenly spaced horizontal joints, with a minimum width of $\frac{1}{8}$ in. (3.2 mm) metric between joints in the plywood.

6.1.5 For the spread of flame test, construct the test deck in the same manner as specified for the intermittent flame test, except that (1) the vertical and horizontal joints need not be provided, (2) the length of the deck shall be as specified in 6.1.6 and (3) $15/32$ -in. (12-mm) thick plywood, conforming to PSI-95, is an acceptable deck for materials or systems when minimal discoloration, without char or no involvement of the plywood test deck occurs, during fire tests. For tests on materials intended for use only on noncombustible decks, a noncombustible deck of the applicable length specified in 6.1.6 is permitted.

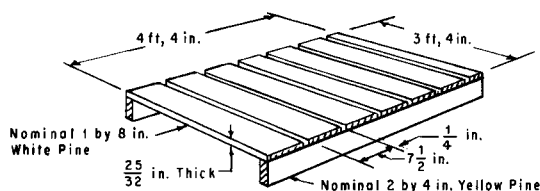
6.1.6 The length of the test deck shall be 13 ft (4.0 m) for Class C tests, 9 ft (2.7 m) minimum for Class B tests, and 8 ft (2.4 m) minimum for Class A tests.



(a) Plywood Decks for Burning Brand Tests

(b) Plywood Decks for Intermittent Flame Tests (Class A or B)

NOTE—Plywood overhangs 2 by 4's by 1/4 at leading edge. 2 by 4 supports are indicated by dotted lines. Plywood joint width: 1/8 in.



(c) Test Decks for Other than Wood Shingles and Shakes (See Appendix X1 for Metric Equivalents.)

FIG. 3 Construction of Test Decks

6.2 Application of Roofing on Test Roof Deck—Apply representative samples of roof covering materials for Class B or C tests to 14 test decks (two each for the spread of flame, intermittent flame, spread of flame, and flying brand tests, four for the burning brand test, and six for the rain test). Apply representative samples of roof covering materials for Class A tests to 16 test decks (two each for intermittent flame, spread of flame, and flying brand tests, four for the burning brand test and six for the rain test). Apply the roof covering materials under investigation in accordance with the manufacturer's instructions and extend to and flush with the edges of the deck, except for a 1-in. (25-mm) overhang at the leading edge. It is permitted to provide an air-seal along the sides of the representative sample of the roof covering material system to restrict air flow under the system during the fire test. The use of a 1-in. (25-mm) maximum width metal batten strip fastened on top of and along each side edge is permitted for mechanically attached single-ply membrane roof covering systems.

NOTE 3—A practice used to provide an air-seal for mechanically attached, fully-adhered and partially-adhered flexible single-ply membrane systems is to pull the membrane taut over the edges of the assembly to fit snugly against the deck and secure it to the wood supports of the test deck.

6.3 Storage and Conditioning of Test Specimens:

6.3.1 Pieces of any hygroscopic materials from the same stock from which the test deck was constructed shall be tacked to the assembly during construction in such a manner that they are easily removed. These pieces shall be conditioned with the completed assemblies as described in 6.3.2.

6.3.2 The completed test assemblies are to be stored indoors at temperatures not lower than 60°F (16°C) nor higher than 90°F (32°C) for the period of time necessary to cure the assembly components. Test decks are to be stored so that each will be surrounded by freely circulating air.

6.3.3 Just before the deck is tested the pieces of hygroscopic materials prepared in 6.3.1 shall be tested for moisture content. (Notes 4 and 5.)

NOTE 4—Make the moisture determination on two samples from each piece and report the average. For lumber and other wood-based materials, use Test Methods D4442. Use of an appropriately calibrated moisture meter, as described in Test Methods D4444, to determine the moisture content of wood or wood products is also permitted. For other hygroscopic materials, use test methods appropriate for those materials.

NOTE 5—For lumber, the moisture content shall not be less than 8 % nor more than 12 %. For plywood, the moisture content shall not exceed 8 %. For other hygroscopic materials, the moisture shall be within ranges specified by the manufacturer before the assembly is constructed. These specified ranges shall be typical for exposure at 77 ± 9°F (25 ± 5°C) and 55 ± 10 % relative humidity. If there is any indication that the lumber,

plywood, or other hygroscopic materials have moisture contents outside these ranges, measure moisture content and replace any out of range materials before building test decks. Out of range pieces shall be dried or rewetted using methods that do not damage the materials.

6.4 The flying brand tests are required when there is a possibility that the roof covering will break into pieces of flying, flaming brands or particles which continue to glow after reaching the floor of the test facility. See Appendix **Appendix X3**.

7. Tests—General

7.1 When a roof covering is restricted for use on noncombustible decks (steel, concrete, or gypsum), only the spread of flame test is required. Materials intended for use only on noncombustible decks are permitted to be tested when applied to a noncombustible deck or any type of combustible deck of the length specified for the spread of flame test.

7.2 When a roof covering is not restricted for use on noncombustible decks, the spread of flame, intermittent flame, and burning brand tests are required.

7.3 The rain tests are required whenever the fire-retardant characteristics of the roof covering materials or construction has the potential to be adversely affected by water. See **Appendix X2**.

7.4 The weathering tests are required for wood shakes and shingles or when the fire-retardant characteristics of the roof covering materials or construction has the potential to be adversely affected by weathering outdoors.

7.5 The flying brand tests are required when there is a possibility that the roof covering will break into pieces of flaming particles that support combustion on the floor. See **Appendix X3**.

7.6 In all of the fire tests described in Sections 8-12, trowel noncombustible mortar into the joint formed by the leading edge of the roof covering material and the framework of the carriage. This is to prevent air or the test flame from traveling under the material being tested.

7.7 In these tests subject all decks to an air current as calibrated in 5.4.

7.8 Test prepared roof coverings at a slope of 5 in. per horizontal ft (416 mm per horizontal m). Test built-up roof coverings at the maximum slope specified by the manufacturer but not to exceed 5 in. per horizontal ft (416 mm per horizontal m). Note the slope used in the report.

8. Intermittent Flame Exposure Test

8.1 Make this test on a minimum of two test decks.

NOTE 6—When the roof covering materials being tested exhibit a variable performance, the use of more than the minimum number of test decks is permitted.

8.2 Mount a test deck 4 ft-4 in. (1.3 m) long on the framework at the required incline and maintain the calibrated air supply to produce the specified air current. Subject the test deck to a luminous gas flame and profile as calibrated in 5.5.

8.3 Apply the flame intermittently for specified periods with specified time intervals between applications as follows:

Class A	2	2	15
Class B	2	2	8
Class C	1	2	3

8.4 Maintain the air current throughout the test and after the last application of flame until all evidence of flame, glow, and smoke has disappeared from both the exposed surface of the material being tested and the underside of the test deck, or until failure occurs, but in no case is the air current or test duration to be maintained for more than 1 h after the last flame cycle for a Class A or B test or ½ h after the last flame cycle for a Class C test.

8.5 During the intermittent flame test, including on and off periods of flame application, observe for the appearance of sustained flaming on the underside of the test deck, production of flaming or glowing brands displacement of portions of the test sample, and exposure or falling away of portions of the roof deck.

9. Spread of Flame Test

9.1 Make this test on a minimum of two test decks (**Note 5**).

9.2 Mount a test deck long enough for the desired Class A, B, or C rating in 6.1.6 in the same manner and use a luminous gas flame as described in 8.2.

9.3 For Classes A and B tests, apply the gas flame and air current continuously for 10 min or until the flame (actual flaming of the material being tested) permanently recedes from a point of maximum spread, whichever is shorter. For Class C test, apply the gas flame and air current for a period of 4 min.

9.4 During the application of the test flame, observe the test sample for the distance to which flaming of the material has spread, production of flaming or glowing brands, and displacement of portions of the test sample.

10. Burning Brand Test

10.1 Make this test on a minimum of four test decks for Class A fire test exposure and two test decks for Class B or C fire test exposure (**Note 6**).

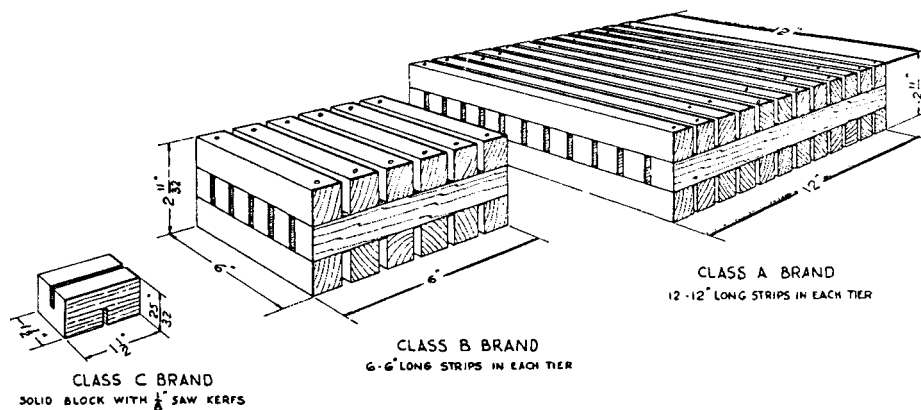
10.2 Mount a 4 ft-4 in. (1.3 m) long test deck in the same manner as described in 8.2 for the intermittent flame test, except that the framework shall be 60 in. (1524 mm) from the air duct outlet (see **Fig. 1**), and the gas piping and burner are removed so as not to obstruct the air flow.

10.3 *Size and Construction of Brands*—Construct the brands (**Fig. 4**), as follows, and condition in an oven at 105 to 120°F (41 to 49°C) for at least 24 h.

10.3.1 The Class A test brand shall consist of a grid 12 in. (305 mm) square and approximately 2¼ in. (57 mm) thick made of dry Douglas fir lumber free of knots and pitch pockets. Use 36 nominal 1 by 1 by 12 in. (25 by 25 by 305 mm) strips, dressed on all four sides to ¾ by ¾ in. (19 by 19 mm), and placed in three layers of twelve strips each with strips spaced ¼ in. (6.35 mm) apart. Place these strips at right angles to those in adjoining layers and nail (**Note 7**) at each end of each strip on one face and in a diagonal pattern (**Fig. 4**) on the other face. The dry weight of the finished brand shall be 2000 ± 150 g at the time of test.

10.3.2 The Class B test brand shall consist of a grid 6 in. (152 mm) square and approximately 2¼ in. (57 mm) thick made of dry Douglas fir lumber free of knots and pitch pockets.

Method of Test	Flame On, min	Flame Off, min	No. of Test Cycles
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(See Appendix X1 for metric equivalents.)

FIG. 4 Brands for Classes A, B, and C Tests

Use 18 nominal 1 by 1 by 6 in. (25 by 25 by 152 mm) strips, dressed on all four faces to $\frac{3}{4}$ by $\frac{3}{4}$ in. (19 by 19 mm), and placed in three layers of six strips each with strips spaced $\frac{1}{4}$ in. (6.35 mm) apart. Place the strips at right angles to those in adjoining layers and nail (Note 7) at each end of each strip on one face and in a diagonal pattern (Fig. 4) on the other face. The dry weight of the finished brand shall be 500 ± 50 g at the time of test.

NOTE 7—Nails used in the construction of Classes A and B brands are No. 16, $1\frac{1}{2}$ in. (38 mm) long bright, flat head, diamond point, wire nails. Sixty-eight nails weighing approximately 42 g are used for Class A brand, and 32 nails weighing approximately 21 g are used for the Class B brand.

10.3.3 The Class C test brand shall consist of a piece of dry nonresinous white pine lumber, free of knots and pitch pockets, $1\frac{1}{2}$ by $1\frac{1}{2}$ by $2\frac{5}{8}$ in. (38 by 38 by 19.8 mm) thick with a saw kerf $\frac{1}{8}$ in. (3 mm) wide, half the thickness of the brand across the center of the top and bottom faces. The saw kerfs on opposite faces shall be at right angles to each other. The dry weight of the finished brand shall be $9\frac{1}{4} \pm 1\frac{1}{4}$ g at the time of the test.

10.4 Ignition of Brands—Before application to the test deck, the brands shall be ignited by subjecting them, for the following required periods of time, to the flame of a gas burner of such size that, during the process of ignition, the brands are enveloped in the burner flame. The flame temperature of the igniting flame shall be $1630 \pm 50^\circ\text{F}$ ($888 \pm 28^\circ\text{C}$) measured $2\frac{5}{16}$ in. (59 mm) above the top of the burner, which is shielded from drafts.

10.4.1 Expose Class A test brands to the flame for 5 min, during which time they shall be rotated to present each surface to the flame in the following manner and sequence:

- Each 12 by 12-in. (305 by 305-mm) face for 30 s;
- Each $2\frac{1}{4}$ by 12-in. (57 by 305-mm) face for 45 s; and
- Each 12 by 12-in. (305 by 305-mm) face again for 30 s.

10.4.2 Expose Class B test brands to the flame for 4 min, during which time they shall be rotated so as to present each surface to the flame in the following manner and sequence:

- Each 6 by 6-in. (152 by 152-mm) face for 30 s;
- Each $2\frac{1}{4}$ by 6-in. (57 by 152-mm) face for 30 s; and
- Each 6 by 6-in. (152 by 152-mm) face again for 30 s

10.4.3 Expose Class C test brands to the flame for 2 min, during which time they shall be rotated so as to present each of the $1\frac{1}{2}$ by $1\frac{1}{2}$ -in. (38 by 38-mm) faces to the flame for 1 min.

10.5 Test Conditions:

10.5.1 Class A Tests:

10.5.1.1 Place a brand on the surface of each test deck at the location considered most vulnerable (point of minimum coverage over deck joint) with respect to ignition of the deck but in no case closer than 4 in. (101 mm) from either side or 12 in. (305 mm) from the top or bottom edge of the deck. Place the brand so that the strips in both the upper and lower layers are parallel to the direction of air flow and with the upper edge of the brand located 3 in. (76 mm) above the horizontal joint in the test deck. Secure to the deck by a No. 18 B & S gage soft iron wire.

10.5.1.2 If the roof covering is being investigated as applied to plywood or other panel type decks, place the brand so that it is centered laterally with respect to the vertical panel joint in the test deck and with the upper edge of the brand located 3 in. (76 mm) above the horizontal panel joint in the test deck.

10.5.2 Class B Tests:

10.5.2.1 Place a brand on the surface of the test deck at each of the two locations considered most vulnerable (point of minimum coverage over deck joint) with respect to ignition of the deck. Position each brand with its upper edge $1\frac{1}{2}$ in. (38 mm) above the selected joint in the deck boards, but in no case closer than 6 in. (152 mm) from each side or 12 in. (305 mm) from the top or bottom edge of the deck. Place the brands so that the lower layers are parallel to the direction of air flow. Secure to the deck by a No. 18 B&S gage (1.02 mm) soft iron wire. The second brand is not to be applied until all burning resulting from the first brand has ceased and the effects from the burning of the first brand will not interfere with the potential fire performance of the test deck when exposed to the second brand.

10.5.2.2 If the roof covering is applied to plywood or other panel type decks, place the brands so they are centered laterally with respect to the vertical panel joints in the test deck and with the upper edge of the brands located $1\frac{1}{2}$ in. (38 mm) above the horizontal panel joint in the test deck.

10.5.3 Class C Tests—At 1 to 2 min intervals, place a brand on the surface of the test deck at each of 20 locations considered most vulnerable (points of minimum coverage over deck joints) with respect to ignition of the deck. Position each brand with its upper edge $\frac{1}{2}$ in. (13 mm) above the selected joint in the deck boards but in no case closer than 6 in. (152 mm) from each side or 12 in. (305 mm) from the top or bottom edge of the deck. Place no brand closer than 4 in. (101 mm) to the point where a previous brand was located. Secure brands by a No. 18 B&S gage (1.02 mm) soft iron wire stretched across the width of the deck and placed in the saw kerf of the brand; the saw kerf on the deck side of the brand is parallel to the direction of air flow.

10.5.3.1 In addition to **10.5.3**, when the roof covering is comprised of lapped courses that are composed of loose or unfastened portions that are capable of being bent up to 90° without injury to the fastenings, cut away the loose or unfastened portions and place the brand so it is not closer than $\frac{1}{2}$ in. (13 mm) from the bottom edge of the lapped course above, nor closer than 2 in. (51 mm) to a joint in the roof covering material in the same course. When the roof covering is comprised of rigid lapped courses, place the brands over a joint in the roof covering material in the course approximately $\frac{1}{2}$ in. (13 mm) from the bottom edge of the lapped course above.

10.5.3.2 If the roof covering is applied to plywood or other panel type decks, place the brands so that as many of the 20 brands as possible are centered over panel joints in the test deck.

10.6 Duration of Test—Continue each individual test, Class A, B, or C, until the brand is totally consumed and until all evidence of flame, glow, and smoke has disappeared from both the exposed surface of the material being tested and the underside of the test deck, or until failure occurs but not for more than $1\frac{1}{2}$ h. Disregard the results of tests in which the brands do not show progressive and substantially complete consumption after application to the test deck. If brands are replaced, do not locate in the same area as the disregarded brand.

10.7 Observations—During and after the burning brand tests, observe for the appearance of sustained flaming on the underside of the test deck, production of flaming or glowing brands of roof covering material, displacement of the test sample, and the exposure or falling away of portions of the roof deck.

11. Flying Brand Test

11.1 Conduct this test on a minimum of two test decks.

11.2 Mount a test deck, 4 ft-4 in. (1.3 m) long in the same manner and use luminous gas flame as described in **8.2** for the intermittent flame test.

11.3 Apply the Classes A and B test gas flame continuously for 10 min. Apply the Class C test flame continuously for 4 min. Maintain the 12-mph (5.4-m/s) air current until all evidence of flame, glow, and smoke has disappeared from the exposed surface of the material being tested to determine if flying brands will be developed. On treated wood shakes the velocity of the air current shall be increased to 18 ± 0.75 mph (8.0 ± 0.3 m/s) after the gas flame is extinguished.

12. Rain Test

12.1 Conduct this test in accordance with Method A of Test Methods **D2898** on six decks.

12.2 Mount test decks 4 ft-4 in. (1.3 mm) long in a framework at a slope of 4 in. per horizontal ft (333 mm per horizontal m). Approximately 7 ft (2.1 m) above the test decks, mount spray nozzles that deliver an average of 0.7 in./h (0.05 mm/s) of water for the test deck area at a temperature between 35 and 60°F (2 and 16°C). Expose the test decks to twelve 1-week cycles. Each cycle consists of 96 h of water exposure and 72 h of drying time at 140°F (60°C).

12.2.1 An alternative test cycle is permitted. Alternately expose two sets of six decks to seven days of water exposure, two days of draining, and five days of curing at 140°F (60°C). Repeat this cycle seven times, except that the seventh water exposure is reduced to six days.

12.2.2 Control the final drying cycle temperature so the moisture content of the deck lumber is from 8 to 12 % (see **Note 2**). For plywood deck the moisture content shall not exceed 8 %.

12.3 Repeat the intermittent flame, burning brand, and flying brand tests in duplicate.

13. Weathering Tests

13.1 **12.1** These test decks are to be mounted outdoors facing south at an incline of 5 in. per horizontal foot (416 mm per horizontal meter). Care shall be taken to protect the deck frame and underside from the effects of the weather. One set of decks shall be prepared for testing and tested after each of 1, 2, 3, 5 and 10 years of exposure. From each set of decks, one deck is to be subjected to the Intermittent Flame Exposure Test (Section **8**), one to the Burning Brand Test (Section **10**) and one to the Flying Brand Test (Section **11**). Prior to testing, the decks are to be conditioned until the deck lumber attains moisture content between 8 % and 12 %. For the plywood decks, the moisture content is to be not greater than 8 %.

14. Conditions of Classification

14.1 A roof covering material shall meet the following conditions when subjected to the particular class of fire tests:

14.2 At no time during or after the intermittent flame, spread of flame, or burning brand tests shall:

14.2.1 Any portion of the roof covering material be blown or fall off the test deck in the form of flaming or glowing brands that continue to glow after reaching the floor,

14.2.2 The roof deck be exposed (**Note 7**) (except for roof coverings restricted to use over noncombustible deck), or

14.2.3 Portions of the roof deck fall away in the form of particles that continue to glow after reaching the floor.

NOTE 8—The deck shall be considered exposed whenever any portion of the deck is visible and without cover from the roof covering material or its residue. The portion of deck directly underneath burning brands and cracks or fissures, $\frac{1}{8}$ in. (3.2 mm) wide or less, shall be excluded from the requirement.

14.3 At no time during the Class A, B, or C intermittent flame or burning brand tests shall there be sustained flaming of

the underside of the deck. If flaming does occur, conduct another series of tests, during which no sustained flaming shall occur.

14.4 During the spread of flame tests, the flaming shall not spread beyond 6 ft (1.8 m) for Class A, 8 ft (2.4 m) for Class B, nor 13 ft (4.0 m) (the top of the deck) for Class C. There shall be no significant lateral spread of flame from the path directly exposed to the test flame.

14.5 In the flying brand test, there shall be no flying, flaming brands, nor particles produced that continue to glow after reaching the floor.

15. Report

15.1 Report the following information:

15.1.1 Description of the roof covering being tested including construction details of the test deck, the manufacturer's application limitations, shelf life, etc., of the roof covering as applicable,

15.1.2 Storage conditions of test roof decks,

15.1.3 Moisture content of the test deck materials and roof covering materials (if moisture absorbing) at the time of testing,

15.1.4 Type and class of test,

15.1.5 Slope of test deck,

15.1.6 Details of the calibration including velocity measurements, flame temperature measurements, heat supply rate, and total water use for rain test,

15.1.7 Type of rain test cycle (if applicable),

15.1.8 Observations of the burning characteristics of the test deck during and after test exposure as detailed in 8.5, 9.4, 10.7, 11.3, and Section 14, and

15.1.9 The class of roof covering (Class A, B, or C).

15.1.10 The climatic conditions of the region where the weathering exposure was conducted as expressed by average daily temperature, average daily wind velocity and average monthly precipitation.

16. Precision and Bias

16.1 Committee E05 is actively pursuing the development of data regarding the precision and bias of these test methods. Data will be included in a future revision of these test methods.

17. Keywords

17.1 burning brands; classification; flying brand; intermittent flame; rain test; roof coverings; roof deck; spread of flame

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APPENDIXES

(Nonmandatory Information)

X1. METRIC EQUIVALENTS

in.	mm	in.	mm	in.	mm	in.	m	ft-in.	mm
1/8	3.2	2 ⁵ / ₁₆	59.0	10 ³ / ₄	273	40	1.02	3-1 ¹ / ₈	0.94
1/4	6.4	2 ¹¹ / ₃₂	59.5	12	305	43 ³ / ₄	1.11	3-4	1.02
1/2	12.7	3	76.2	13 ¹ / ₂	343	44	1.12	4-0	1.22
		3 ¹ / ₂	88.9						
0.7	17.8	3 ⁵ / ₈	92.0	14	356			4-0 ¹ / ₄	1.225
3/4	19.0	3 ¹¹ / ₁₆	93.6	20	508	60	1.52	4-4	1.32
2 ⁵ / ₃₂	19.8	4	101.6	24	610			4-4 ¹ / ₂	1.33
2 ⁹ / ₃₂	23.0	4 ¹ / ₂	114.3	28	712			4-7 ³ / ₄	1.42
1	25.4	5	127.0	29	736			4-8	1.44
1 ¹ / ₄	31.7	6	152.4	30	762			7-0	2.13
1 ¹ / ₂	38.1	7	178.0	33	838			8-0	2.44
1 ⁵ / ₈	41.3	7 ¹ / ₂	190.5	35	889			12-0	3.66
2	50.8	9 ¹ / ₄	235.0	36	914			13-0	3.96
2 ¹ / ₄	57.1	10	254.0						

°F	°C	Dressed Wood Dimensions		
		nominal in.	actual in.	actual mm
35	2.0			
50	10.0			
60	15.5	1 by 4	3/4 by 3 ¹ / ₂	19 by 88.9
90	32.2	1 by 8	3/4 by 7 ¹ / ₂	19 by 190.5
140	60.0	1 by 1	3/4 by 3/4	19 by 19
212	100.0		1 ¹ / ₂ by 1 ¹ / ₂ by 2 ⁵ / ₃₂	38.1 by 38.1 by 19.8
220	104.4			
1300	704.4			
1400	760.0			
1630	887.0			

X2. RAIN TEST⁵

X2.1 Asphalt shingles meeting Specifications **D225** or **D3018** have been shown not to have their fire-retardant characteristics adversely affected by prolonged exposure to water.

⁵ Donahue, R. L., and Castino, G. T., "Fire Performance of New Roof Covering Materials and Systems and Weathered Asphalt Shingles," *Roofing Systems, ASTM STP 603*, ASTM, 1976, pp. 51–56.

X2.2 Gravel, slag, mineral, or smooth surfaced built-up roof constructions utilizing asphalt and coal tar roofing products, meeting Specifications **D226**, **D227**, **D312**, **D450**, **D1227**, **D2178**, **D2626**, **D3158**, **D3378**, or **UL 55A**, have been shown not to have their fire-retardant characteristics adversely affected by prolonged exposure to water.

X2.3 Slate, concrete, clay tile, and metal roofing are considered as not being adversely affected by prolonged exposure to water.

X3. FLYING BRAND TEST

X3.1 Asphalt shingles meeting Specifications **D225** or **D3018** have been shown to comply with the flying brand test requirements. Similar available evidence indicates that gravel, slag, mineral, or smooth surfaced built-up roof constructions utilizing asphalt and coal tar roofing products meeting Speci-

fications **D226**, **D227**, **D312**, **D450**, **D1227**, **D2178**, **D2626**, **D3158**, **D3378**, **D3462**, or **UL 55A** comply with flying brand test requirements. Other materials also exhibiting compliance with flying brand test requirements are slate, concrete clay, tile, and metal roofing.

X4. COMMENTARY ON FIRE TESTS OF ROOF COVERINGS

X4.1 Introduction

X4.1.1 This commentary has been developed to provide the user of Test Methods E108 with an historic background on the development of fire tests for roofing materials and to provide a degree of guidance to the user of the test and test results and those concerned with developing a test program, interpreting results, and making a reasoned judgment in applying the results.

X4.1.2 It appears that the first fire tests on roofing materials were developed at Underwriters Laboratories, Inc., (UL) in 1903 **(1)**⁷ to permit standardized evaluation of roof coverings in terms of their ability to withstand ignition, fire spread, and fire penetration from exterior fires. The National Fire Protection Association Committee on Devices and Materials presented a report on classification of roof coverings that was adopted in 1910. **(2-4)** This early standard had three tests and one research task:

X4.1.2.1 Flame exposure test,

X4.1.2.2 Burning brand test,

X4.1.2.3 Radiation test, and

X4.1.2.4 Durability investigation to determine the quality of the raw materials employed, the weathering qualities, and the necessity for repairs and renewals in the roof covering as applied to the roof structure.

X4.1.3 The materials tested were divided into five general classes, A through E, and each general class could be subdivided to accommodate special applications and roof construction. The test deck was formed with kiln-dried nominal 1 by 8 in. (25.4 by 203.2 mm) white pine boards. One test criterion for classification was little or no burn through of the white pine decking.

X4.1.4 In the flame exposure test, a wind velocity of 5 mph (2 m/s) and also 40 mph was directed against the roofing during the tests for periods up to 5 h. The slope of the roof varied depending on intended use up to 45°.

X4.1.5 In the burning brand test, a maple wood crib was placed on the roof covering to determine its resistance to ignition, fire spread, and burn through under the same slope and wind conditions.

X4.1.6 The radiation tests consisted of exposing the roofing to the radiant heat of a circular steel plate 36 in. (914.4 mm) in diameter heated to a constant temperature of 1200°F (650°C) under the same conditions.

X4.1.7 The durability study was an examination as to the physical and chemical makeup of the roofing materials, physical properties of the roof itself, and an historic review of past performance.

X4.1.8 Between 1903 and 1917, UL classified roofing materials in accordance with these standards, dropping to three classes, A, B, and C, by 1917. **(5,6)** About this time, UL adopted standard specifications for Shingle Roof Coverings (Asbestos Cement); Asphalt Rag-Felt; Prepared Roof Cover-

ings and Class C, Asphalt Organic-Felt Sheet Roofing and Shingles for use with the Fire Test. **(6,7)**

X4.1.9 Somewhat different considerations affected the approach in Great Britain, and the British Fire Prevention Committee published a report of tests on various roofing materials and roof designs in 1910. **(8)** The tests were run in accordance with procedures established for these specific investigations. Full details of tests were not given. England did not adopt regulations until additional studies were made in 1947, and the first standard was issued in 1958. **(9-12)**

X4.1.10 At its meeting in September 1921, the Dominion Fire Prevention Association in Canada resolved to investigate roof coverings. A comprehensive series of fire tests were conducted by a committee, and a report was given on April 29, 1926. **(13)** The tests used were considered to simulate three exposure conditions: direct flame from adjacent building; radiant heat from a nearby fire; and burning brands. Some improvements in the standard tests were recommended in this report. A subsequent report was issued in 1927. In these tests, the classifications were I, II, and III. A Class I covering had to resist burn through during the flaming tests for 40 min. Class II was a 25-min test. Class III had to pass only the brand test. It is not clear when the radiant exposure was dropped as a test criterion. Also, no further correspondence or records are available between 1927 and 1955.

X4.1.11 Following the formation of the subcommittee on roof coverings, ASTM first published Test Methods E108 in 1955 as a tentative standard. In order to exclude performance criteria from a test method, the letter classifications A, B, and C were used to designate classes of fire test exposure rather than classes of roof covering. These methods were revised in 1958 and reaffirmed in 1970. Between 1970 and 1975 changes were made to these methods with regard to format and test criteria. The present edition was published in 1975. Underwriters Laboratories, Inc., has been a leader in developing and performing tests of roofing materials and published a similar roof covering test method (UL 790). The National Fire Protection Association (NFPA) also publishes a similar test method, NFPA No. 256. The following paragraphs provide additional background information on certain sections of the method.

X4.1.12 As part of the overall evaluation of the roof covering under the simulated fire exposures, a condition was set under **14.2.2** that the roof deck should not be left unprotected (exposed) as a consequence of the fire exposure. Roof coverings restricted for use only on noncombustible decks (steel, concrete, or poured gypsum) require only the spread of flame test (see **7.1**). Based on this circumstance, the condition for deck exposure for such roof coverings relates only to the potential for the roof covering to spread flame. Exposure of portions of noncombustible deck inherently will not contribute to fire spread over the roof surface. Further consideration was given toward roof coverings that consist of thin polymeric coatings or membranes over steel concrete that should not be

⁷ The boldface numbers in parentheses refer to the list of references at the end of these test methods.

precluded from evaluation under these test methods. In consideration of the above, the requirement under 14.2.2 was amended to exclude noncombustible deck.

X4.2 Scope and Significance (Sections 1 and 4)

X4.2.1 These test methods are intended to provide a means of ranking roof-covering materials according to their ability to resist spread of flame burn through of the decking, and the development of flying burning material when subjected to a variety of fire test exposure. The roof covering materials are subjected to test conditions considered to be representative of fire exposures likely to originate outside the building. A rain test is conducted where the fire retardant characteristics of the roof covering may be adversely affected by prolonged exposure to weather.

X4.2.2 Three classes of fire test exposure (Classes A, B, and C tests) are provided to establish the performance of roof coverings against severe (Class A), moderate (Class B), and light (Class C) fire exposures. Building codes may require that the building roofs provide some degree of resistance to fire penetration into the building relative to these exposures.

X4.3 Decks (6.1 and 6.2)

X4.3.1 The standard deck for all test assemblies is one constructed of No. 1 white pine lumber, 1 by 8 in. nominal with a moisture content from 8 to 12 % by weight. (See 6.1 and 6.3.) Paragraph 6.1.2 details the requirements for a spaced-board deck that is required for roofing material such as wood shingles, which are traditionally supported in this manner. Since burn through to the underside of decking is an important criterion, it is necessary to measure such results where no deck is utilized (for example, roof panels applied directly to rafters or purlins). Where other decks such as plywood are used, it shall be reported.

X4.4 Conditioning (6.3)

X4.4.1 The completed roof-deck test specimens are stored indoors for not more than 60 days under controlled temperature conditions. There is a requirement that the roof covering material shall be tested not sooner than 30 nor later than 60 days after manufacture (after treating wood roof coverings). This requirement allows a reasonable time for asphalt roofing materials to cure.

X4.5 Air Currents (5.4)

X4.5.1 The test requires a constant air current of 12 ± 0.5 mph (5.3 ± 0.2 m/s) applied uniformly over the top surface, and measured at three specific locations on a calibration deck inclined at 5 in. per horizontal ft (0.416:1) as indicated by the standard.

X4.6 Slope of Deck (7.5)

X4.6.1 Tests shall be conducted with the deck either at a slope of 5 in./ft (127 mm/m) (prepared roof coverings) or at the

maximum slope recommended for use (built-up roof coverings). From experience of UL and research, including the references cited earlier in this commentary, the performance of the roofing material appears to improve as the slope decreases from 5 in./ft. Other research has been done in this area, but no definite conclusions can be drawn.

X4.7 Number of Tests (8.1-10.1 and 11.1)

X4.7.1 Experience indicates that, for most roofing materials, all required tests should be run on a minimum of two specimens. The standard requires, however, that additional specimens will be tested where the results of the first two tests show a significant difference in performance.

X4.8 Flying Brand Test (Section 11)

X4.8.1 This test is used to determine the tendency of a roof covering material to develop flying brands as described in Section 10. However, it is required that any flying brands developed during any of the fire tests be noted. A flying brand is defined as “any part of the roof covering material which is still flaming or glowing when it reaches the test room floor.”

X4.9 Rain Test (Section 12 and Appendix X2)

X4.9.1 The rain test was introduced in 1975 to provide a means for determining whether fire-retarding chemicals will leach out due to water exposure. At the present time, fire-retardant-treated wood shingles and shakes are the only roofing materials normally subjected to the rain test.

X4.9.2 Specimens that have been subjected to the rain test are dried and tested by the intermittent flame, burning brand, and flying brand test methods. The rain test is designed to simulate an 80-in. (2032-mm) rainfall per year for a period of 10 years. Test Methods D2898 have two test methods (exposures) described, but only Method A is applicable to Test Methods E108.

X4.9.3 Test Methods E108 recognize in Appendix X2 specific generic roof covering materials that have demonstrated by prior test experience their resistance to fire exposure after extensive weathering. The effect of weathering on asphalt shingles has been investigated and reported by UL. (12)

X4.10 Summary

X4.10.1 The tests define the performance of a roof-covering material under specific test fire conditions. They do not provide information on the performance of roof-covering materials under other conditions or in actual fire situations.

X4.10.2 There is no direct basis of comparison between the results of the various classes of tests since each class has a different fire source and a different fire application. Conditions of classification are also different for each class of test.

X4.10.3 There is no test to measure the performance of roofing materials when exposed only to radiant heat flux.

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